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CERTIFICATE OF TRANSLATION

I, TAKESHI OSHIO, patent attorney of Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-ku, Osaka 540-6015, Japan HEREBY CERTIFY that I am acquainted with the English and Japanese languages and that the attached English translation is a true English translation of what it purports to be, a translation of Japanese Patent Application No. 2002-48258 filed on 25 February, 2002 in the name of SHARP KABUSHIKI KAISHA.

Dated this 18th day of July 2007

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(Translation)

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[List of the Documents]

[Item]	Specification	1
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[Name of the Document] SPECIFICATION

[Title of the Invention] CHARACTER DISPLAY APPARATUS AND CHARACTER DISPLAY METHOD, CONTROL PROGRAM FOR CONTROLLING THE CHARACTER DISPLAY METHOD AND RECORDING MEDIUM RECORDING THE CONTROL PROGRAM

[Scope of the Claims]

[Claim 1] A character display apparatus, comprising

a display section having a character displayed thereon; and

a control section for controlling the display section,

wherein

a display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements is assigned to each sub-pixel,

the control section determines, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character, extracts an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels, and determines luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 2] A character display apparatus according to claim 1, wherein the control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when a position of the sub-pixel corresponding to the basic portion is replaced with a position of its neighboring pixel.

[Claim 3] A character display apparatus according to claim 1, wherein the control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when, in addition to the sub-pixel corresponding to the basic portion, its neighboring sub-pixel is duplicated as the basic portion.

[Claim 4] A character display apparatus according to claim 1, wherein the control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to a combination of a character color and a background color to be displayed.

[Claim 5] A character display apparatus according to claim 1, wherein the control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to the size of the difference between character and background colors previously registered and character and background colors to be displayed.

[Claim 6] In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a method for displaying a character on a display surface of the display section, comprising the steps of:

determining, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extracting an arrangement of sub-pixels

corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determining luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 7] In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a control program used when a character is displayed on a display surface of the display section, having a procedure described thereon for causing the control section to:

determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 8] A recording medium readable by a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, the recording medium including a control program recorded thereon having a procedure described thereon for

causing the control section to:

determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to: a character display apparatus, including a display section capable of displaying color, capable of displaying characters with high resolution; a character display method; a control program for controlling the character display method; and a recording medium having the control program recorded thereon.

[0002]

[Prior Art]

Some personal computers, word processors, mobile telephones and the like include a display section capable of displaying color. As a technique for displaying characters with high resolution in such apparatuses, for example, Japanese Laid-Open Publication No. 2001-100725 discloses the following character display apparatus.

[0003]

This character display apparatus is provided with a plurality of pixels on a display surface of the display apparatus. Each pixel includes a plurality of sub-pixels arranged in a predetermined direction, to which a respective color

element (e.g., Red (R), Green (G), and Blue (B)) is assigned. The strength of a color element in a sub-pixel is represented by the level of the color element set in a plurality of steps, e.g., 0 to 7. If a certain level of color element is assigned to a sub-pixel corresponding to the skeleton of a character, color element levels which vary stepwise around the sub-pixel are assigned to its surrounding sub-pixels. The color element levels are set in a predetermined pattern. Each color element level is converted to a luminance level based on a predetermined correspondence.

[0004]

The level of a color element corresponds to the degree of the color element which contributes to the color of a character. Therefore, the greater the contribution of a sub-pixel to the color of a character, the greater the color element level of the sub-pixel. The greater the contribution of a sub-pixel to the color of a background, the lower the color element level of the sub-pixel. In addition, the luminance level of a sub-pixel corresponds to the degree of light emission of the sub-pixel. The greater the luminance level of a sub-pixel, the greater the degree of light emission of the sub-pixel. The lower the luminance level, the lower the degree of light emission. Thus, by controlling the color element level on a sub-pixel-by-sub-pixel basis so as to represent the shapes of characters, the characters can be displayed with higher resolution than when the luminance level is controlled on a pixel-by-pixel basis. Further, by forming a pattern of color element levels which vary stepwise around a sub-pixel corresponding to the skeleton of a character, color noise can be suppressed.

[0005]

Further, Japanese Laid-Open Publication No. 2001-184051 discloses another character display apparatus capable of

displaying characters with high resolution in any character color and any background color, by appropriately changing a predetermined correspondence between the above-described color element level and luminance level according to the color of a character to be displayed and the color of a background.

[0006]
Figure **12** is a block diagram showing a representative configuration of a character display apparatus disclosed in Japanese Laid-Open Publication No. 2001-100725 and Japanese Laid-Open Publication No. 2001-184051 described above.

[0007]
As the character display apparatus **1a**, any information display apparatus including a display device capable of displaying color, such as an electronic apparatus, an information apparatus, and the like can be used. Examples of the character display apparatus **1a** also include personal computers and word processors of any type, such as desktop, laptop, and the like. Further, an electronic apparatus including a color liquid crystal display device can be used. Still further, communication apparatuses (e.g., personal digital assistants, mobile telephones including PHS, general fixed telephones, FAX, etc.) can be used.

[0008]
The character display apparatus **1a** includes a display device **3**. This display device **3** is capable of displaying color. Examples of the display device **3** include liquid crystal displays, organic EL displays, and the like.

[0009]
The display device **3** is connected to a control section **20**. The control section **20** includes a CPU **2** and a main memory **4**.

The control section **20** can separately control a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. An input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**.

[0010]
The input device **7** is an apparatus for inputting characters to be displayed on the display device **3**, instructions of an operator, and the like. Examples of the input device **7** include keyboards, touch panels, mice, and the like.

[0011]
The auxiliary memory apparatus **40** stores a display program **41a** for displaying characters, and data **5** including character shape data **5b**, a correction table **5c** and a luminance table **5d**. Examples of the character shape data **5b** include outline data representing the contour shapes of characters, skeleton data representing the skeletal shapes of characters, bitmap data representing characters, and the like. Note that processing by the display program **41a** varies slightly depending on the type of the character shape data **5b**. Characters to be displayed may include simple graphics, such as pictographic characters and the like. In the descriptions below, characters are illustrated.

[0012]
The correction table **5c** is used to set the color element levels of sub-pixels neighboring a sub-pixel corresponding to a basic portion. For example, when the color element level of a sub-pixel corresponding to a basic portion is 7, the color element levels of its neighboring sub-pixels are set to be, for example, 5, 2 and 1 from the nearest to the basic portion. In addition, the luminance table **5d** defines a correspondence between color element levels and

luminance levels.

[0013]
Portion **(a)** of Figure **13** and Portion **(b)** of Figure **13** are diagrams for explaining the configuration of a display surface of the display device **3**. The display surface of the display device **3** is provided with a plurality of pixels **10** for representing characters, graphics to be displayed, and the like as shown in Portion **(a)** of Figure **13**. Each pixel **10** includes 3 sub-pixels **11** arranged in a predetermined direction (a horizontal direction in the figure), to which respective color elements (e.g., Red (R), Green (G), and Blue (B)) are assigned.

[0014]
When a character is displayed on the display surface, the basic portion representing the skeleton of the character is associated with sub-pixels **11** included in each pixel **10** to be displayed, based on the character shape data **5b**. For example, when a Kanji character "忙" is displayed, sub-pixels indicated by hatched portions shown in Figure **9** are associated with the sub-pixels **11** as the basic portion representing the skeleton of the character.

[0015]
When associating the basic portion representing the skeleton of a character with sub-pixels **11**, a different process is performed depending on the type of the character shape data **5b**. For example, outline data contains a character code for identifying the type of a character, the number of strokes constituting a single character (the stroke count of a character), the number of contour points constituting a single stroke, the coordinates of contour points constituting a single stroke, and the like. In this case, each stroke has a shape enclosed by a contour line approximated by curved lines, straight lines, arcs, a

combination thereof, or the like, and a predetermined thickness so as to represent the contour shape of a character. A contour line representing the contour shape of a character can be approximated by straight lines, curved lines, arcs, a combination thereof, or the like, using the coordinate data of contour points. If an area where the inside of a contour line overlaps a sub-pixel is greater than or equal to a predetermined area, such a sub-pixel is determined as a basic portion representing the skeleton of a character.

[0016]

In addition, skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke (curved line, straight line, or the like), the coordinates of points constituting a single stroke, and the like. In this case, each stroke is in the form of a line corresponding to a certain line type for representing the skeletal shape of a character, and does not have a thickness. If the line type of a stroke is a straight line, the stroke can be approximated by a straight line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. If the line type of a stroke is a curved line, the stroke can be approximated by a curved line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. Sub-pixels 11 positioned on a stroke are determined as sub-pixels 12 corresponding to the basic portion representing the skeleton of a character.

[0017]

When a sub-pixel 12 corresponding to the basic portion representing the skeleton of a character is determined, the color element levels of the sub-pixel 12 and a sub-pixel 13

neighboring the sub-pixel **12** are set. For example, when a sub-pixel **12** (hatched in Portion **(b)** of Figure **13**), which is located at the middle of three sub-pixels **11** (Portion **(a)** of Figure **13**) constituting a pixel **10**, is determined to correspond to a basic portion, the color element level of the sub-pixel **12** corresponding to the basic portion is set, as shown in Portion **(b)** of Figure **13**, to be "7" which is the maximum level. In addition, the color element levels of sub-pixels **13** which neighbor the sub-pixel **12** corresponding to the basic portion and are determined not to correspond to the basic portion, are set based on the correction table **5c** whose example is shown in Figure **10**. For example, when a correction pattern **1** is selected, the color element levels of the sub-pixels **13** which neighbor the sub-pixel **12** corresponding to the basic portion are set to be stepwise decreased, e.g., "5", "2", and "1" with an increase in the distance from the sub-pixel **12** corresponding to the basic portion. In addition, when a correction pattern **2** is selected, the color element levels of the sub-pixels **13** which neighbor the sub-pixel **12** corresponding to the basic portion, are set to be stepwise decreased, e.g., "4", "2", and "1" with an increase in the distance from the sub-pixel corresponding to the basic portion. Further, the color element level of sub-pixels **14**, which are located at a distance of four pixels or more from the sub-pixel **12** corresponding to the basic portion, is set to be "0" as a background.

[0018]

Note that when a sub-pixel **13**, which is determined not to correspond to a basic portion, neighbors a plurality of sub-pixels **12** corresponding to the basic portion, a plurality of color element levels may be set for the sub-pixel **13** depending on the distance from the plurality of sub-pixels **12** corresponding to the basic portion. In such a case, the color element level of the sub-pixel **13** is set to be the

greatest value.

[0019]
The color element level of each sub-pixel is converted to a luminance level based on a correspondence between color element levels and luminance levels set in the luminance table **5d** shown in Figure **11**. In the example of Portion **(b)** of Figure **13**, the luminance level of the sub-pixel **12** corresponding to the basic portion is set to be "0". The luminance level of a sub-pixel having a color element level of "5", which neighbors the sub-pixel **12**, is set to be "73". The luminance level of a sub-pixel having a color element level of "2" is set to be "182". The luminance level of a sub-pixel having a color element level of "1" is set to be "219". The luminance level of the sub-pixel **14**, whose color element level is set to "0" as a background, is set to be "255".

[0020]
Figure **14** is a flowchart showing a process flow of the display program **41a** when the character shape data **5b** is skeleton data.

[0021]
In step S1, a character code and a character size are input from the input device **7**. For example, when a Kanji character "木" is displayed on the display device **10**, 4458 (JIS KUTEN code, 44th section and 58th point) is input as a character code. The character size is represented by the number of dots in a horizontal direction and the number of dots in a vertical direction of a character to be displayed, e.g., 20 dots × 20 dots, for example.

[0022]
In step S2, skeleton data corresponding to the input character code is read from the character shape data **5b** in

the auxiliary memory apparatus **40** and is then stored in the main memory **4** of the control apparatus **20**. This skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke, the coordinates of points constituting a single stroke, and the like.

[0023]

In step S3, the coordinate data of points constituting each stroke contained in the skeleton data is scaled according to the character size input from the input device **7**. This scaling converts the coordinate data contained in the skeleton data defined in a predetermined coordinate system to a real pixel coordinate system for the display device **10**. In this case, the scaling is performed by considering the arrangement of sub-pixels. As shown in Portion **(a)** of Figure **13**, for example, one pixel **10** includes three sub-pixels **11** arranged in an X direction, and when a character size is 20 dots × 20 dots, the coordinate data of the skeleton data is scaled into data of 60(=20×3) pixels × 20 pixels.

[0024]

In step S4, the coordinate data of points constituting a single stroke is retrieved. In step S5, it is determined whether the type of stroke is a straight line or a curved line from the line type of the stroke contained in the skeleton data. When the type of stroke is a straight line, the process goes to step S6. When the type of stroke is a curved line, but not a straight line, the process goes to step S7.

[0025]

In step S6, the coordinate data of the points constituting the stroke are linked with straight lines, and sub-pixels positioned on the straight lines are defined as the basic portion representing the skeleton of a character. In

step S7, the coordinate data of the points constituting the stroke is approximated by curved lines, and sub-pixels positioned on the curved lines are defined as the basic portion representing the skeleton of a character.

[0026]

In step S8, the color element level of the sub-pixel corresponding to the basic portion representing the skeleton of the character, which is defined in step S6 or step S7 described above, is set to be the maximum color element level, for example, "7". Next, in step S9, the color element levels of sub-pixels neighboring the sub-pixel corresponding to the basic portion are set according to the correction table **5c**.

[0027]

In step S10, it is determined whether or not all strokes contained in a character have been processed. If "Yes", the process goes to step S11. If "No", the process returns to step S3 and is repeated. In step S11, the color element levels of the set sub-pixels are converted to respective luminance levels according to the luminance table **5d** indicating the correspondence between color element levels and luminance levels. In step S12, luminance data indicating the luminance levels of the sub-pixels set in step S11 is transferred to the display device **3**.

[0028]

In this manner, luminance levels are adjusted on a sub-pixel-by-sub-pixel basis to display a character on the display device **3**. In this case, sub-pixels corresponding to the basic portion representing the skeleton of a character are derived from the skeleton data. Alternatively, such sub-pixels may be derived from outline data, bitmap data, or the like by a predetermined process. Alternatively, the pattern of the basic portion which is previously stored as

character shape data in the auxiliary memory apparatus **40** may be read and used.

[0029]

[Problems to be Solved by the Invention]

However, in the above-described conventional technique, a pattern of the color element levels of sub-pixels constituting the shape of a character is set, and thereafter, the color element levels are converted to respective luminance levels which are actually to be displayed on a display section. Therefore, the process is complicated and a working memory area required for performing the process is increased. As a result, there are problems that character display processing is slowed, the hardware cost is increased, and the like.

[0030]

In addition, in the above-described conventional technique, when two or more strokes having a predetermined width are near to or cross each other, the space portion within a character is reduced so that it is difficult to recognize the shape of the character, i.e., "deformed character". To avoid this, a pattern of the color element levels of sub-pixels is changed. However, there is a problem that a complicated task is required in order to change a pattern of color element levels by actually recognizing the positional relationship between strokes.

[0031]

Further, when arbitrary colors are set to characters and backgrounds to be displayed, in some combination of the color of a character and the color of a background, a pattern of color element levels of sub-pixels is not suitable for representing the colors of the set character and background, thus causing a problem that the shape of the character is degraded and the visibility of the character is significantly

reduced.

[0032]
The present invention is intended to solve such problems of the conventional technique. The objective of the present invention is to provide: a character display apparatus and a character display method capable of displaying characters with high resolution and definition by a simple process, wherein the speed of character display processing is increased and the hardware cost can be decreased; a control program for controlling the character display method; and a recording medium having the control program recorded thereon.

[0033]
[Means for Solving the Problems]
A character display apparatus according to the present invention includes: a display section having a character displayed thereon; and a control section for controlling the display section, wherein a display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements is assigned to each sub-pixel, the control section determines, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character, extracts an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels, and determines luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0034]

The control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when a position of the sub-pixel corresponding to the basic portion is replaced with a position of its neighboring pixel.

[0035]

The control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when, in addition to the sub-pixel corresponding to the basic portion, its neighboring sub-pixel is duplicated as the basic portion.

[0036]

The control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to a combination of a character color and a background color to be displayed.

[0037]

The control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to the size of the difference between character and background colors previously registered and character and background colors to be displayed.

[0038]

In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a method according to the present invention for displaying a character on a display surface of the display section, includes the steps of: determining, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion

representing a skeleton of a character based on character shape data representing a shape of a character; extracting an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determining luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0039]

In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a control program according to the present invention is used when a character is displayed on a display surface of the display section, having a procedure described thereon for causing the control section to: determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character; extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0040]

A recording medium according to the present invention readable by a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a

corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, the recording medium includes a control program recorded thereon having a procedure described thereon for causing the control section to: determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character; extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0041]
Functions of the present invention will be described below.

[0042]
According to the present invention, the display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, wherein at least a corresponding one of a plurality of color elements is assigned to each sub-pixel. When displaying a character on the display surface of the display section, sub-pixels corresponding to the basic portion representing the skeleton of a character are determined from the plurality of sub-pixels based on character shape data representing the shapes of characters, such as skeleton data representing the skeletal shapes of characters, outline data representing the contour shapes of characters, bitmap data representing the shapes of characters, or the like. From sub-pixels contained in a pixel whose luminance level is to be determined and its neighboring sub-pixels are determined, the arrangement of

the sub-pixels corresponding to the basic portion is extracted. Based on the extracted arrangement pattern of sub-pixels, the luminance levels of sub-pixels are determined, and the character is displayed on the display section.

[0043]
Therefore, as compared to a conventional technique in which the color element level of a sub-pixel corresponding to a basic portion and the color element levels of sub-pixels neighboring the sub-pixel corresponding to the basic portion are determined before the color element levels are used to determine the color luminance level of a pixel of interest, when displaying characters with high resolution and high definition, since luminance levels can be determined only by extracting arrangements of sub-pixels corresponding to a basic portion, processes can be simplified and the processes can be performed at practical speed even using a CPU having a low processing speed. Further, the size of a control program describing a procedure can be reduced, thereby making it possible to reduce the size of an auxiliary memory apparatus. Furthermore, the simplification of processes can reduce a working memory region required during processing. As a result, the cost of a character display apparatus can be reduced, thereby making it possible to realize a character display with high resolution and high definition.

[0044]
In addition, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the position of a sub-pixel corresponding to a basic portion is replaced with its neighboring sub-pixel. Based on such a replacing arrangement, the luminance levels of sub-pixels can be determined. Therefore, when

sub-pixels corresponding to the skeleton of a character are close to each other, the arrangement of sub-pixels can be changed so that such sub-pixels are spaced further apart. Thereby, it is possible to prevent a space between strokes of the character from being diminished, which deforms the character when strokes of the character are close to each other. The arrangement of sub-pixels corresponding to the skeleton of a character may not be suitable for the representation of the character, depending on a color combination of a character and a background. Even in this situation, by changing the arrangement of sub-pixels corresponding to the skeleton, distortion of the character can be corrected.

[0045]
Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, in addition to a sub-pixel corresponding to a basic portion, its neighboring sub-pixel is duplicated as a basic portion. Based on the duplicated arrangement, the luminance levels of the sub-pixels can be determined. Thus, a sub-pixel corresponding to the skeleton of a character can be multiplexed, thereby making it possible to simplify a process of thickening the line width of a character so that the process can be efficiently performed.

[0046]
Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels can be changed depending on a combination of a character color and a background color to be displayed. Therefore, the optimum luminance levels of sub-pixels can be determined

depending on a character color and a background color. Therefore, characters having an optimum line width can be displayed for each color combination, whereby characters can be displayed with a high level of visibility irrespective of the color combination.

[0047]

Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels can be changed according to the size of the difference between character and background colors previously registered and character and background colors to be displayed. Therefore, the above-described correspondence can be shared by a group of characters having similar color combinations (similar luminance levels of sub-pixels), whereby characters can be displayed with a greater variety of color combinations and an optimum line width while suppressing the storage capacity of a character display apparatus to a low level.

[0048]

[Embodiment of the Invention]

Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

[0049]

Figure 1 is a block diagram showing a configuration of a character display apparatus according to an embodiment of the present invention. As the character display apparatus **1b**, any information display apparatus including a display device capable of displaying color, such as an electronic apparatus, an information apparatus, and the like can be used. Examples of the character display apparatus **1b**

also include personal computers and word processors of any type, such as desktop, laptop, and the like. Further, examples of the character display apparatus **1b** also include electronic apparatuses including a color liquid crystal display device, such as communication apparatuses (e.g., personal digital assistants, mobile telephones including PHS, general fixed telephones, FAX, etc.).

[0050]
The character display apparatus **1b** includes a display device **3**. This display device **3** is capable of displaying color. Examples of the display device **3** include liquid crystal displays, organic EL displays, and the like.

[0051]
The display device **3** is connected to a control section **20**. The control section **20** includes a CPU **2** and a main memory **4**. The control section **20** can separately control a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. An input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**.

[0052]
The input device **7** is an apparatus for inputting characters to be displayed on the display device **3**, instructions of an operator, and the like. Examples of the input device **7** include keyboards, touch panels, mice, and the like.

[0053]
The auxiliary memory apparatus **40** stores a display program **41b** for displaying characters and data **5** containing character shape data **5b** and a pixel value table **5e**. Examples of the character shape data **5b** include outline data representing the contour shapes of characters, skeleton data representing the skeletal shapes of characters, bitmap data

representing characters, and the like. Note that processing by the display program **41b** varies slightly depending on the type of the character shape data **5b**. Characters to be displayed may include simple graphics, such as pictographic characters and the like. In descriptions below, characters are illustrated.

[0054]

The pixel value table **5e** contains a correspondence between the arrangement pattern of a basic portion comprising M+2×N sub-pixels including M sub-pixels contained in a pixel (pixel of interest) whose luminance level is determined and N sub-pixels neighboring each side of the M sub-pixels, and the luminance levels (pixel value) of the M sub-pixels contained in the pixel of interest.

[0055]

Portion **(a)** of Figure **2** to Portion **(c)** of Figure **2** are diagrams for explaining the configuration of a display surface of the display device **3**. The display surface of the display device **3** is provided with a plurality of pixels **10** for representing characters, graphics to be displayed, and the like as shown in Portion **(a)** of Figure **2**. Each pixel **10** includes 3 sub-pixels **11** arranged in a predetermined direction (a horizontal direction in the figure), to each of which a corresponding color element of a plurality of color elements (e.g., Red (R), Green (G), and Blue (B)) is assigned.

[0056]

When a character is displayed on the display surface, the basic portion representing the skeleton of the character is associated with sub-pixels **11** included in pixels **10** to be displayed, based on the character shape data **5b**. For example, when a Kanji character "忙" is displayed, the basic portion representing the skeleton of the character is

associated with sub-pixels **11** indicated by hatched portions shown in Figure **9**.

[0057]

When the basic portion representing the skeleton of a character is associated with sub-pixels **11**, a different process is performed depending on the type of the character shape data **5b**. For example, outline data contains a character code for identifying the type of a character, the number of strokes constituting a single character (the stroke count of a character), the number of contour points constituting a single stroke, the coordinates of contour points constituting a single stroke, and the like. In this case, each stroke has a shape enclosed by a contour line approximated by curved lines, straight lines, arcs, a combination thereof, or the like, and a predetermined thickness so as to represent the contour shape of a character. A contour line representing the contour shape of a character can be approximated by straight lines, curved lines, arcs, a combination thereof, or the like, using the coordinate data of contour points. If an area where the inside of a contour line overlaps a sub-pixel is greater than or equal to a predetermined area, such a sub-pixel is determined to correspond to a basic portion representing the skeleton of a character.

[0058]

In addition, skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke (curved line, straight line, or the like), the coordinates of points constituting a single stroke, and the like. In this case, each stroke is in the form of a line corresponding to a certain line type for representing the skeletal shape of a character, and does not have a thickness. If the line

type of a stroke is a straight line, the stroke can be approximated by a straight line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. If the line type of a stroke is a curved line, the stroke can be approximated by a curved line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. Sub-pixels **11** positioned on a stroke are determined as sub-pixels **12** corresponding to the basic portion representing the skeleton of a character.

[0059]

The bitmap data has binary values. Each bit constituting the bitmap data has a value of "1" or "0". A bit having a value of "1" represents a black portion in a graphic. A bit having a value of "0" represents a white portion in a graphic. A basic portion of a graphic corresponds to a core in a graphic. When a graphic is a character, the basic portion is, for example, a middle portion of a stroke contained in a character. However, in the bitmap data, stroke information is lost. Thus, bits in the bitmap data are associated with the basic portion by inference. The basic portion cannot be inferred only by information of bit D(x, y) of interest. However, the basic portion is inferred based on information of neighboring bits around bit D of interest. It is initially determined whether or not each bit constituting the bitmap data is "1", so as to examine the "1"/"0" arrangement pattern of neighboring bits around the bit of interest. The bit of interest is associated with a pixel. Among the sub-pixels contained in the pixel to which the bit of interest corresponds, a sub-pixel **12** corresponding to the basic portion is determined according to the arrangement pattern of the neighboring bits.

[0060]

Figure **15** is a diagram showing a portion of bitmap data representing a graphic. D(x, y) represents a bit of interest. N(a, b) represents neighboring bit D(x+a, y+b) around D(x, y). Figure **15** shows eight neighboring bits N(-1, 1), N(0, -1), N(1, -1), N(-1, 0), N(1, 0), N(-1, 1), N(0, 1), and N(1, 1) neighboring bit D(x, y) in a vertical, horizontal, or slant direction. These eight neighboring bits are called eight neighbors. N(a, b) and D(x, y) each have a value of "1" or "0".

[0061]

Figure **16** is a diagram showing a portion of the display surface of a display device. P(x, y) represents a pixel on the display surface. Bit D(x, y) shown in Figure **15** is associated with pixel P(x, y) when a graphic represented by bitmap data is displayed on a display device. P(x, y) contains three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y). When D(x, y) has a value of "1", a sub-pixel corresponding to a basic portion is determined among the three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y) according to a basic-portion definition rule. When D(x, y) has a value of "0", none of the three sub-pixels is determined as a sub-pixel corresponding to the basic portion. Note that although bit D(x, y) shown in Figure **15** is associated with a sub-pixel group **Grp** shown in Figure **16**, the number of sub-pixels contained in a group and the number of sub-pixels contained in a pixel are not necessarily equal to each other. For example, a bit in the bitmap data may be associated with a group **Grp**' consisting of four sub-pixels shown in Figure **16**. In addition, the direction of arrangement of sub-pixels contained in a group is not limited to an X direction. For example, a bit in the bitmap data may be associated with a group **Grp**" in which sub-pixels are arranged in the X direction and the Y direction shown in Figure **16**.

[0062]

Figure **17A** shows an example of 8 neighboring bits of a bit of interest D(x, y) in the bitmap data. Bit N(a, b) having a value of "1" is represented by N(a, b). In Figure **17A**, N(0, -1) = N(1, 1) = 1, N(1, 0) = N(0, 1) = N(-1, 1) = N(-1, 0) = 0, and N(-1, -1) and N(1, -1) represented by "※" has any one of "0" and "1". Figure **17B** is a diagram showing a sub-pixel which is associated with the basic-portion according to a basic-portion definition rule when 8 neighboring bits of bit D(x, y) have values shown in Figure **17A**. According to the basic-portion definition rule, whether or not each of three sub-pixels contained in pixel P(x, y) is associated with a basic portion is determined according to the arrangement of "0" and "1" of neighboring bits N(a, b) around bit D(x, y) associated with pixel P(x, y) as follows. Note that bit D(x, y) is assumed to have a value of "1" in the description below. As shown in Figure **15**, pixel P(x, y) on the display surface associated with bit D(x, y) contains three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y). Among these sub-pixels, a sub-pixel indicated by a value of "1" in Figure **17B** is associated with a basic portion, while sub-pixels indicated by a value of "0" are not associated with a basic portion. Specifically, sub-pixel C(3x+2, y) is associated with a basic portion, while C(3x, y) and C(3x+1, y) are not associated with a basic portion. For example, in the bitmap data shown in Figure **17A**, a stroke is inferred to be a curved line (dashed line **50** in Figure **16A**) which passes through areas corresponding to bits N(0, -1), D(x, y), and N(1, 1). Such a curved line is considered to pass through the right-hand side of an area corresponding to bit D(x, y). Therefore, in Figure **17B**, sub-pixel C(3x+2, y) on the right-hand side of pixel P(x, y) corresponding to bit D(x, y) is associated with a basic portion.

[0063]

When a sub-pixel **12** corresponding to the basic portion representing the skeleton of a character is determined, the color element levels of the sub-pixel **12** and a sub-pixel **13** neighboring the sub-pixel **12** are determined. For example, when a sub-pixel **12** (hatched in Portion **(b)** of Figure **2**), which is located at the middle of three sub-pixels **11** (Portion **(a)** of Figure **2**) constituting a pixel **10**, is determined to correspond to a basic portion, the color element level of the sub-pixel **12** corresponding to the basic portion is set, as shown in Portion **(b)** of Figure **2**, to be "7" which is the maximum level. In addition, the color element levels of sub-pixels **13** which neighbor the sub-pixel **12** corresponding to the basic portion and are determined not to correspond to the basic portion, are set to be stepwise decreased, e.g., "5", "2", and "1" with an increase in the distance from the sub-pixel **12** corresponding to the basic portion. Further, the color element level of sub-pixels **14**, which are located at a distance of four pixels or more from the sub-pixel **12** corresponding to the basic portion, is set to be "0" as a background.

[0064]
Note that when a sub-pixel **13**, which is determined not to correspond to a basic portion, neighbors a plurality of sub-pixels **12** corresponding to the basic portion, a plurality of color element levels may be set for the sub-pixel **13** depending on the distance from the plurality of sub-pixels **12** corresponding to the basic portion. In such a case, the color element level of the sub-pixel **13** is set to be the greatest value.

[0065]
The color element level of each sub-pixel is converted to a luminance level based on to a correspondence between color element levels and luminance levels. In the example of Portion **(b)** of Figure **2**, the luminance level of the

sub-pixel **12** corresponding to the basic portion is set to be "0". In addition, the luminance level of a sub-pixel having a color element level of "5", which neighbors the sub-pixel **12**, is set to be "73". The luminance level of a sub-pixel having a color element level of "2" is set to be "182". The luminance level of a sub-pixel having a color element level of "1" is set to be "219". The luminance level of the sub-pixel **14**, whose color element level is set to "0" as a background, is set to be "255".

[0066]
When a luminance level is determined in this manner, in the present embodiment, as shown in Portion **(c)** of Figure **3**, the arrangement of a basic portion is extracted from M+2×N sub-pixels including M sub-pixels **16** contained in a pixel (pixel of interest) **15** whose luminance level is to be determined and N sub-pixels **17** neighboring on each side of pixel **15**. Based on the extracted arrangement pattern, the luminance levels (i.e., pixel value) of M sub-pixels **16** contained in the pixel **15** of interest are determined.

[0067]
Figure **3** is a diagram showing an example of the pixel value table **5e**. In Figure **3** and Figures **4** to **7**, the description will be given regarding the case in which the number (M) of the sub-pixels **16** contained in the pixel **15** of interest shown in Portion **(c)** of Figure **2** is 3 (M=3), and the number (N) of the sub-pixels **17** neighboring on each side of the pixel **15** is 3 (N=3). Note that the number N of the above-described pixels is typically the same as the number of elements in a correction pattern (N=3 in Figure **10**). The left-hand side of Figure **3** shows an arrangement pattern of 9 sub-pixels contained in 3 pixels (the pixel **15** of interest and pixels on the both sides thereof) which are arranged in the same direction as that of the arrangement of the sub-pixels. In the figure, element "0" indicates that a

basic portion is not assigned to a sub-pixel relating to the element; element "1" indicates that a basic portion is assigned to a sub-pixel relating to the element; and element "x" indicates that either a basic portion is assigned to a sub-pixel relating to the element or a basic portion is not assigned to a sub-pixel relating to the element. In addition, the right-hand side of Figure **3** shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest corresponding to the arrangement pattern on the left side of Figure **3**.

[0068]
The pixel value of a pixel is determined using the pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value (the luminance levels of sub-pixels) is to be determined.

[0069]
For example, in the case in which the arrangement of sub-pixels corresponding to a basic portion is "x10 000 01x", for example, when the correction pattern 1 shown in Figure **10** is selected, the arrangement of the color element levels is "x75, 212, 57x". The color element levels (2, 1, 2) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 219, 182) according to the correspondence between color element levels and luminance levels shown in Figure **11**. Therefore, in the pixel value table **5e** of Figure **3**, the arrangement pattern "x10 000 01x" of the sub-pixels corresponding to a basic portion and the pixel values (182, 219, 182) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0070]
Figure **4** is a diagram showing another example of the pixel value table **5e**. The left-hand side of Figure **4** shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. The right-hand side of Figure **4** shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest corresponding to the arrangement pattern on the left side of Figure **4**.

[0071]
The pixel value of a pixel is determined using the pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0072]
For example, in the case in which the arrangement of sub-pixels corresponding to a basic portion is "000 001 000", when the correction pattern 1 shown in Figure **10** is selected, the arrangement of the color element levels is "001, 257, 521". The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 73, 0) according to the correspondence between color element levels and luminance levels shown in Figure **11**. Therefore, in the pixel value table **5e** of Figure **4**, the arrangement pattern "000 001 000" of the sub-pixels corresponding to a basic portion and the pixel values (182, 73, 0) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0073]
As described above, the correspondence between the

arrangement pattern of sub-pixels corresponding to a basic portion and the luminance values of the sub-pixels is preset in the pixel value table 5e. Therefore, when sub-pixels corresponding to a basic portion are near each other, the pixel values of pixels present between strokes of a character can be controlled by adjusting the luminance values of sub-pixels corresponding to the arrangement pattern. Therefore, it is possible to prevent black pixels from filling between strokes of a character, i.e., space within the character is diminished, or the like. Thus, the quality of display can be improved.

[0074]

Figure 5 is a diagram showing another example of the pixel value table 5e. Herein, a basic portion is moved so as to prevent a space within a character from being diminished. The left-hand side of Figure 5 shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. In addition, the middle of Figure 5 shows an arrangement pattern, in which sub-pixels corresponding to a basic portion are replaced with the sub-pixels located at the middle of three sub-pixels contained in each pixel. The right-hand side of Figure 5 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the middle of Figure 5.

[0075]

The pixel value of a pixel is determined using the pixel value table 5e indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0076]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "000 001 000", the arrangement of the sub-pixels is changed to "000 010 000" by replacement of the basic portion. Due to this, when the correction pattern 1 shown in Figure 10 is selected, the arrangement of the color element levels is "012, 575, 210", and the color element levels (5, 7, 5) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (73, 0, 73) according to the correspondence between color element levels and luminance levels shown in Figure 11. Therefore, in the pixel value table 5e of Figure 5, the arrangement pattern "000 001 000" of the sub-pixels corresponding to a basic portion and the pixel values (73, 0, 73) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0077]

Figure 6 is a diagram showing another example of the pixel value table 5e. Herein, a duplicate of a basic portion is provided on the left side of the basic portion to thicken the line width of a character (multiplexing). The left-hand side of Figure 6 shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels and a sub-pixel neighboring on the right-hand side thereof. The middle of Figure 6 shows an arrangement pattern, in which in addition to a sub-pixel corresponding to a basic portion, a sub-pixel located on the left-hand side of that pixel is duplicated as a basic portion. The right-hand side of Figure 6 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the middle of Figure 6.

[0078]

The pixel value of a pixel is determined using the pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0079]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "x10 000 01x x", the arrangement of the sub-pixels is changed to "x10 010 11x x" by providing a duplicate of the basic portion to the left-hand side of the sub-pixel. Due to this, when the correction pattern 1 shown in Figure **10** is selected, the arrangement of the color element levels is "x75, 225, 77x, x". The color element levels (2, 2, 5) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 182, 73) according to the correspondence between color element levels and luminance levels shown in Figure **11**. Therefore, in the pixel value table **5e** of Figure **6**, the arrangement pattern "x10 000 01x x" of the sub-pixels corresponding to a basic portion and the pixel values (182, 182, 73) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0080]

Figure **7** is a diagram showing another example of the pixel value table **5e**. Figure **7** shows a correspondence between the arrangement of sub-pixels corresponding to a basic portion and the pixel values (R, G, B) of pixels, where the color of a background is orange, i.e., (R, G, B) = (255, 127, 0). The left-hand side of Figure **7** shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. The right-hand side of Figure **7** shows

the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the left-hand side of Figure 7.

[0081]

The pixel value of a pixel is determined using the pixel value table 5e indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0082]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "000 000 000", there is no sub-pixel corresponding to the basic portion of a character. A pixel whose pixel value is to be determined corresponds to a background. Therefore, the luminance value of (R, G, B) is (255, 127, 0).

[0083]

The color element levels of sub-pixels neighboring a basic portion, which are stepwise changed, are adjusted according to the distribution of luminance in the background color. For example, in the case in which the arrangement of sub-pixels corresponding to the basic portion is "000 001 000", when the background color is white, the arrangement of color element levels is "001,257,521" as shown in Figure 4. The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 73, 0). In contrast, when the background color is orange, the ratio of the luminance levels (R, G, B) is (1, 1/2, 0). Therefore, the color element levels (2, 5, 7) of the sub-pixels (R, G, B) contained in the pixel of interest whose pixel value is to be determined are adjusted to luminance levels (182, 36, 0) where the level of G becomes $73 \times 1/2 \cong 36$.

Thus, in the pixel value table **5e** of Figure **7**, the arrangement pattern "000 001 000" of the sub-pixels corresponding to the basic portion and the adjusted pixel values (182, 36, 0) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0084]

A correspondence between the arrangement of sub-pixels and the pixel value of a pixel to be set for arbitrary character color and background color can be adjusted according to the character color and background color based on the pixel value table **5e** indicating a correspondence for a basic color combination, i.e., black characters in a white background as shown in Figures **3** and **4**. For each color combination, the pixel value of a pixel can be determined according to a pixel value table **5e** as shown in Figure **7**.

[0085]

For each combination of a character color and a background color, a pixel value table as shown in Figure **7** described above may be provided, or the values of a pixel value table as shown in Figures **3** and **4** described above may be adjusted so as to determine a correspondence between the arrangement of sub-pixels and a pixel value. Further, when there are a number of combinations of a character color and a background color, similar colors may be grouped and pixel value tables indicating a correspondence are provided for respective representative colors, and pixel value tables indicating a correspondence may be adjusted according to the size of a difference between the character and background colors and the representative color. For example, the sum of squares of differences between each color element (R, G, B), the sum of absolute differences between each color element (R, G, B), or the like, can be used as an indicator for determining the size of a color difference. A difference

in color element level in color space (e.g., YUV space, Lab space, or the like) according to visual characteristics may be used as an indicator for determining a color difference. If a difference between a representative color assigned to the above-described pixel value table indicating a correspondence and a color specified in displaying a character is less than or equal to a predetermined threshold, the specified color is determined as a color belonging to a group including the representative color and the pixel value table can be used to determine the pixel value of a pixel.

[0086]

The above-described pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels and the pixel value of a pixel has $2^{(M+2\times N)}$ entries of arrangement combinations of sub-pixels, i.e., the combinations of the presence or absence ("1" or "0") of a basic portion in (M+2×N) sub-pixels. For example, if M=N=3, the number of entries is 512. As shown in Figure **10**, however, correction patterns are set, in which the color element levels of sub-pixels neighboring a sub-pixel corresponding to a basic portion are stepwise changed. Therefore, the sequence of the luminance values of sub-pixels is limited. In addition, when correction patterns overlap in a sub-pixel, the larger color element level is set in the sub-pixel. Therefore, the number of pixel values obtained by combinations of sub-pixels is 5×N+8 where M=3. Therefore, if M=N=3, the number of pixel values is 23. By assigning 23 indexes to 512 arrangement patterns, a data capacity required for storing pixel values actually set can be reduced as compared to when a total of 24-bit full color data is prepared in a table where each of (R, G, B) has a length of 8 bit (=0 to 255), for example. However, note that the number of combinations described above is not limited to 23 obtained from the above-described expression in order to set pixel

values more precisely.

[0087]
As described above, in a correspondence between the arrangement of sub-pixels and luminance levels of pixels, the sub-pixel of interest is arranged in a direction along which, for example, R, G, and B are arranged. However, the present invention is not so limited. Alternatively, a similar correspondence can be used for other arrangements, for example in the case in which the sub-pixel of interest is arranged in a direction perpendicular to which, for example, R, G, and B are arranged.

[0088]
Figure **8** is a flowchart indicating a process flow of the display program **41b** when the character shape data **5b** is skeleton data.

[0089]
In step S1, a character code and a character size are input from the input device **7**. For example, when a Kanji character "木" is displayed on the display device **10**, 4458 (JIS KUTEN code, 44th section and 58th point) is input as a character code. The character size is represented by the number of dots in a horizontal direction and the number of dots in a vertical direction of a character to be displayed, e.g., 20 dots × 20 dots, for example.

[0090]
In step S2, skeleton data corresponding to the input character code is read from the character shape data **5b** in the auxiliary memory apparatus **40** and is then stored in the main memory **4** of the control apparatus **20**. This skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke,

the line type of a stroke, the coordinates of points constituting a single stroke, and the like.

[0091]

In step S3, the coordinate data of points constituting each stroke contained in the skeleton data is scaled according to the character size input from the input device **7**. This scaling converts a predetermined coordinate system for the coordinate data contained in the skeleton data to a real pixel coordinate system defined for the display device **10**. In this case, the scaling is performed by considering the arrangement of sub-pixels. As shown in Portion **(a)** of Figure **13**, for example, one pixel **10** includes three sub-pixels **11** arranged in an X direction, and when a character size is 20 dots × 20 dots, the coordinate data of the skeleton data is scaled into data of 60(=20×3) pixels × 20 pixels.

[0092]

In step S4, the coordinate data of points constituting a single stroke is retrieved.

[0093]

In step S5, it is determined whether the type of the stroke is a straight line or a curved line from the line type of the stroke contained in the skeleton data. When the type of the stroke is a straight line, the process goes to step S6. When the type of the stroke is a curved line, but not a straight line, the process goes to step S7.

[0094]

In step S6, the coordinate data of the points constituting the stroke are linked with straight lines, and sub-pixels positioned on the straight lines are defined as the basic portion representing the skeleton of a character. In step S7, the coordinate data of the points constituting the stroke is approximated by curved lines, and sub-pixels

positioned on the curved lines are defined as the basic portion representing the skeleton of a character.

[0095]
In step S10, it is determined whether or not all strokes contained in a character have been processed. If "Yes", the process goes to step S101. If "No", the process returns to step S3 and is repeated.

[0096]
In step S101, the arrangement of sub-pixels corresponding to a basic portion representing a skeleton of a character defined in above-described step S6 or step S7 is extracted from the sub-pixels contained in a pixel whose pixel value (the luminance levels of sub-pixels) is to be determined and from its neighboring sub-pixels.

[0097]
In step S102, a pixel value corresponding to the arrangement pattern of the basic portion extracted in step S101 is set as the luminance levels of sub-pixels contained in the pixel of interest according to the pixel value table **5e** indicating a correspondence between the arrangement pattern of sub-pixels corresponding to a basic portion and the pixel value (the luminance levels of sub-pixels) of a pixel.

[0098]
In step S12, luminance data indicating the luminance levels of the sub-pixels set in step S102 is transferred to the display device 3.

[0099]
As described above, the luminance level can be adjusted on a sub-pixel-by-sub-pixel basis based on the arrangement of sub-pixels corresponding to a basic portion for the purpose of displaying a character on the display device 3. Herein,

sub-pixels corresponding to the basic portion representing the skeleton of a character are derived from skeleton data. Alternatively, such sub-pixels may be derived from outline data, bitmap data, or the like by a predetermined process. Alternatively, the pattern of the basic portion which is previously stored as character shape data in the auxiliary memory apparatus **40** may be read and used.

[0100]

[Effect of the Invention]

As described above, according to the present invention, when a character is displayed with high resolution on a display section capable of displaying color, a luminance level to be displayed on the display section can be obtained directly by converting the arrangement of sub-pixels corresponding to the basic portion representing the skeleton of a character. Therefore, the character display process can be performed at a higher rate and a working memory area for performing the character display process can be reduced. As a result, character display processing can be performed at a higher rate and the hardware cost can be reduced.

[0101]

In addition, when character strokes are close to each other, the positions of sub-pixels corresponding to the basic portion representing the skeleton of a character can be adjusted to easily prevent deformation of a character. Further, in addition to a sub-pixel corresponding to the basic portion representing the skeleton of a character, the arrangement of its neighboring sub-pixels is adjusted so as to be a sub-pixel for the basic portion, thereby making it possible to easily increase the line width of the character.

[0102]

Further, in the case in which arbitrary color is set to a

character and a background to be displayed, it is possible, by changing a correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels according to the character color and the background color, to provide a character display in which the shape of a character is retained and a high level of visibility is achieved irrespective of a color combination.

[0103]

Further, in a correspondence between the arrangement of sub-pixels corresponding to a basic portion and the pixel value of a pixel, similar combinations of a character color and a background color may be grouped for arbitrary combination of characters and backgrounds so as to be merged into a correspondence table for a representative color combination. Therefore, a data amount required for a correspondence table between the arrangement of sub-pixels corresponding to a basic portion and the pixel value of a pixel can be reduced.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a block diagram showing a configuration of a character display apparatus according to an embodiment of the present invention.

[Figure 2]

Portions (a) to (c) of Figure 2 are diagrams for explaining a configuration of sub-pixels and a correction pattern in a character display apparatus according to an embodiment of the present invention.

[Figure 3]

Figure 3 is a diagram showing an example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 4]
Figure **4** is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 5]
Figure **5** is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 6]
Figure **6** is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 7]
Figure **7** is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 8]
Figure **8** is a flowchart for explaining a character display method according to an embodiment of the present invention.

[Figure 9]
Figure **9** is a diagram showing an exemplary pattern of sub-pixels corresponding to a basic portion for a Kanji character "忙".

[Figure 10]
Figure **10** is a diagram showing an exemplary correction table in a conventional character display apparatus.

[Figure 11]
Figure **11** is a diagram showing an exemplary luminance table

in a conventional character display apparatus.

[Figure 12]
Figure **12** is a block diagram showing a configuration of a conventional character display apparatus.

[Figure 13]
Portions **(a)** and **(b)** of Figure **13** are diagrams for explaining a configuration of sub-pixels and a correction pattern in a conventional character display apparatus.

[Figure 14]
Figure **14** is a flowchart for explaining a conventional character display method.

[Figure 15]
Figure **15** is a diagram showing a portion of bitmap data representing graphics.

[Figure 16]
Figure **16** is a diagram showing a portion of a display surface of a display device.

[Figure 17A]
Figure **17A** is a diagram showing an example of a bit of interest and its 8 neighbors in bitmap data.

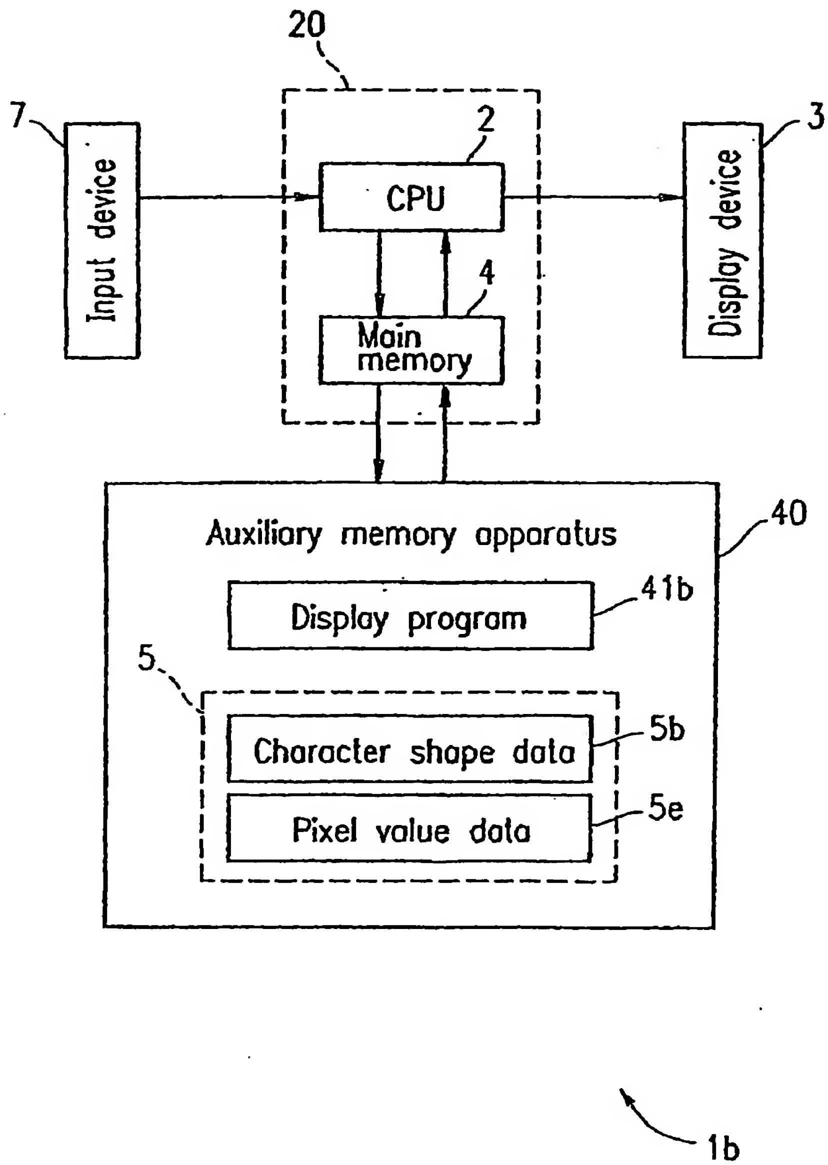
[Figure 17B]
Figure **17B** is a diagram showing a sub-pixel associated with a basic portion according to a basic-portion definition rule in the bit of interest and its 8 neighbors shown in Figure **17A**.

[Description of the Reference Numerals]
1a, 1b character display apparatus
2 CPU
3 display device

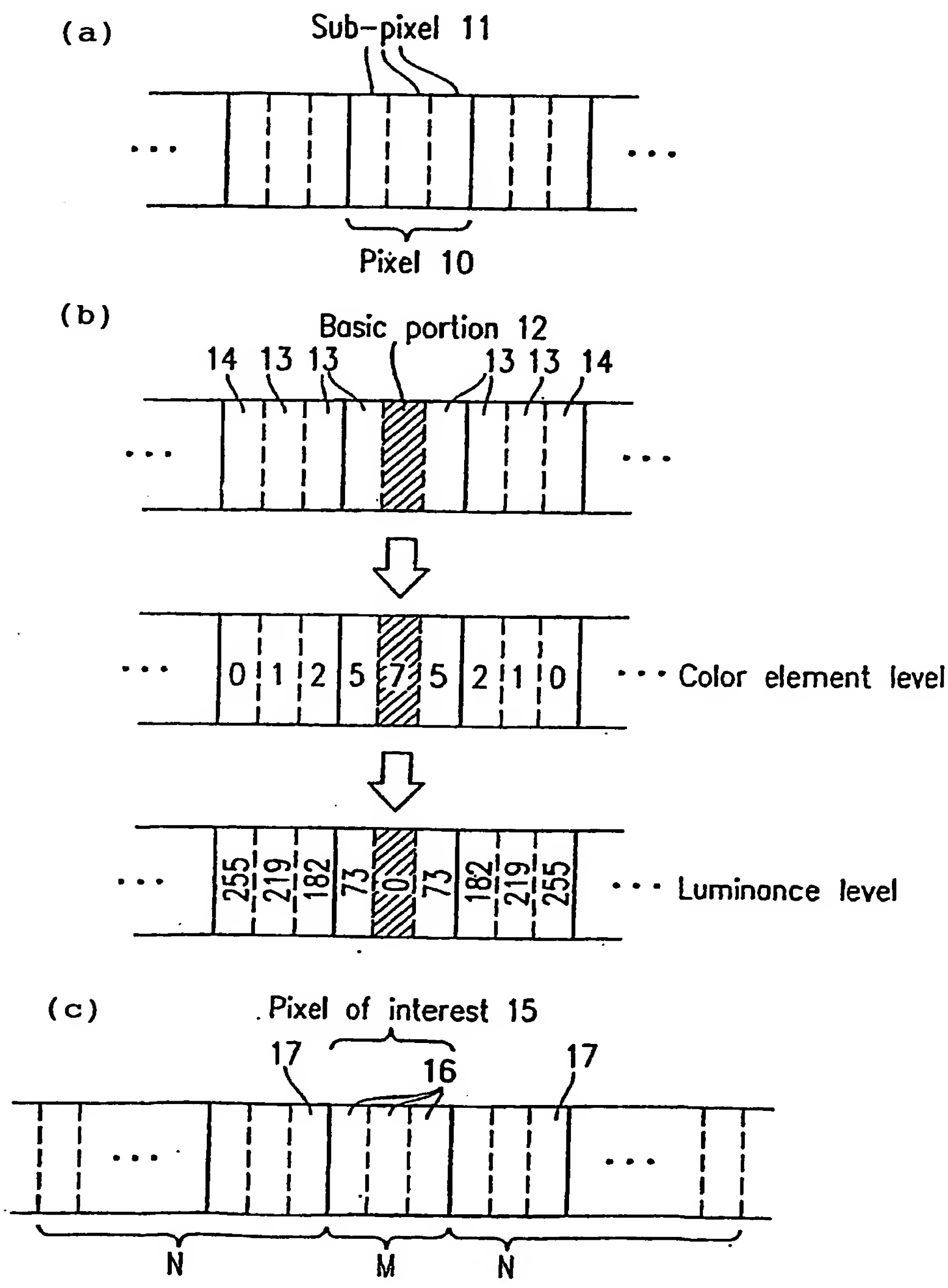
4 main memory
5 data
5b character shape data
5c correction table
5d luminance table
5e pixel value table
7 input device
10 pixel
11 sub-pixel
12 sub-pixel corresponding to the basic portion representing the skeletal shape of a character
13 sub-pixel which neighbors the sub-pixel corresponding to a basic portion
14 sub-pixel which is located at a distance of four pixels or more from the sub-pixel corresponding to the basic portion
15 pixel of interest
16 sub-pixel contained in the pixel of interest
17 sub-pixel which neighbors the pixel of interest
40 auxiliary memory apparatus
41a, 41b display program

[Name of the Document] DRAWINGS

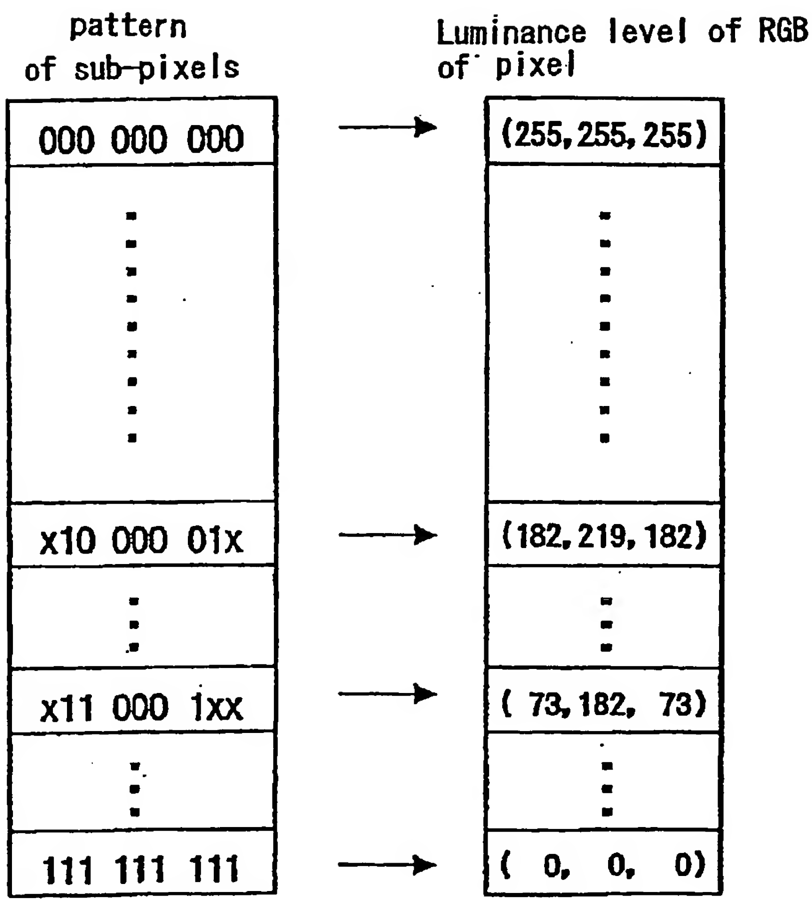
[Figure 1]



[Figure 2]


(a)
Sub-pixel 11
Pixel 10
(b)
Basic portion 12
14 13 13 13 13 14
0 1 2 5 7 5 2 1 0
Color element level
255 219 182 73 0 73 182 219 255
Luminonce level
(c)
Pixel of interest 15
17
16
17
N
M
N

[Figure 3]



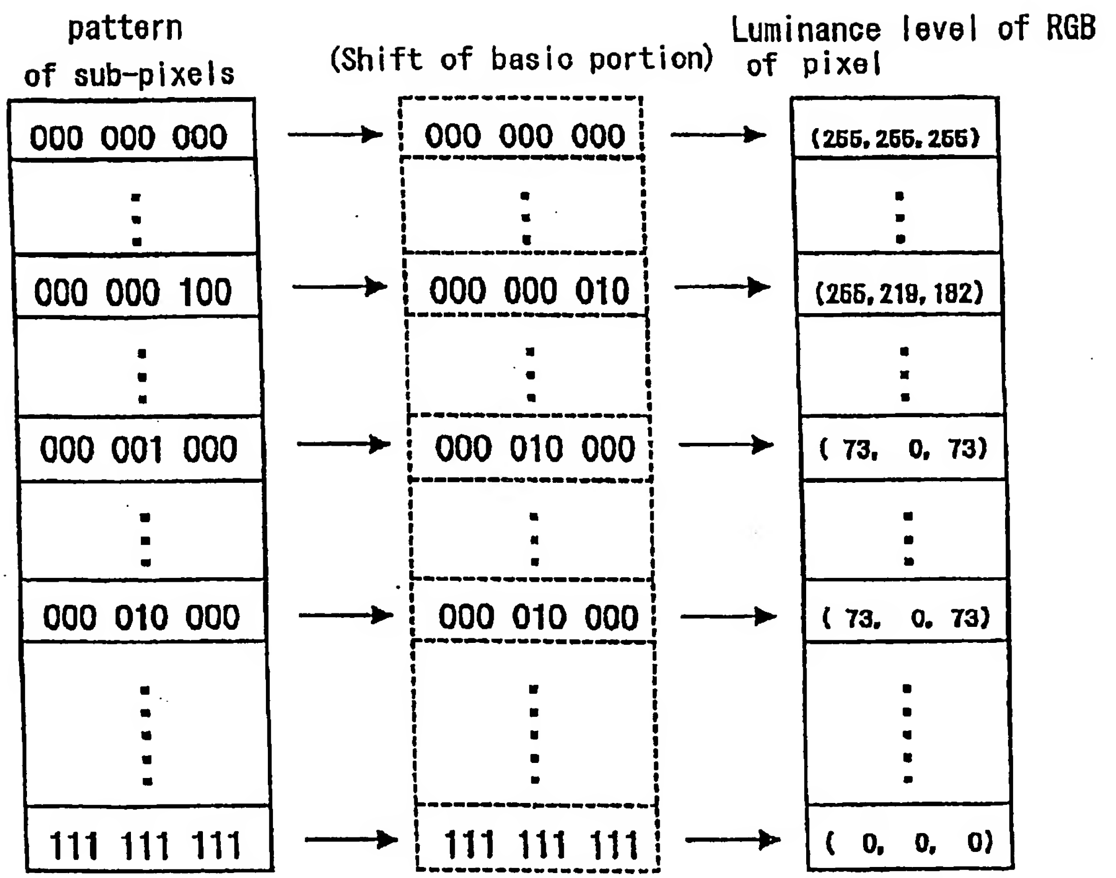
Example of N=M=3

[Figure 4]

pattern of sub-pixels		Luminance level of RGB of pixel
000 000 000	→	(255, 255, 255)
⋮		⋮
000 000 100	→	(219, 182, 73)
⋮		⋮
000 001 000	→	(182, 73, 0)
⋮		⋮
000 010 000	→	(73, 0, 73)
⋮		⋮
111 111 111	→	(0, 0, 0)

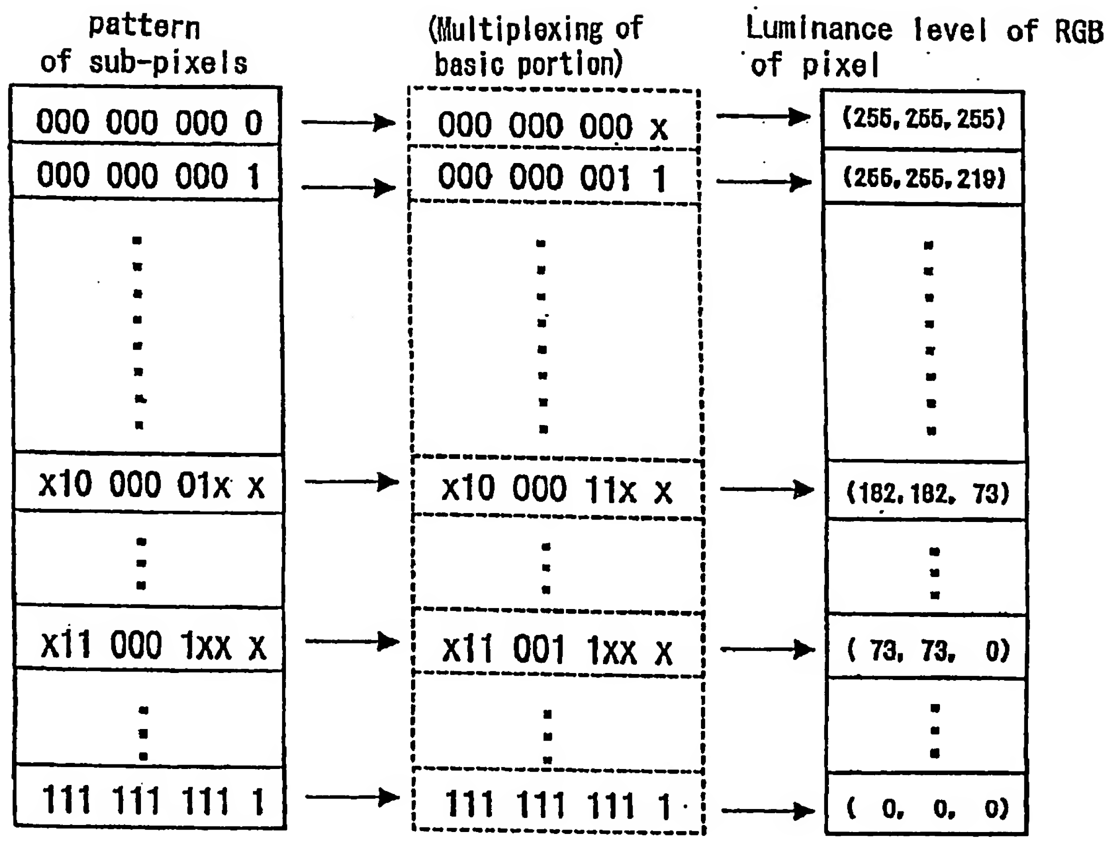
Example of N=M=3

[Figure 5]



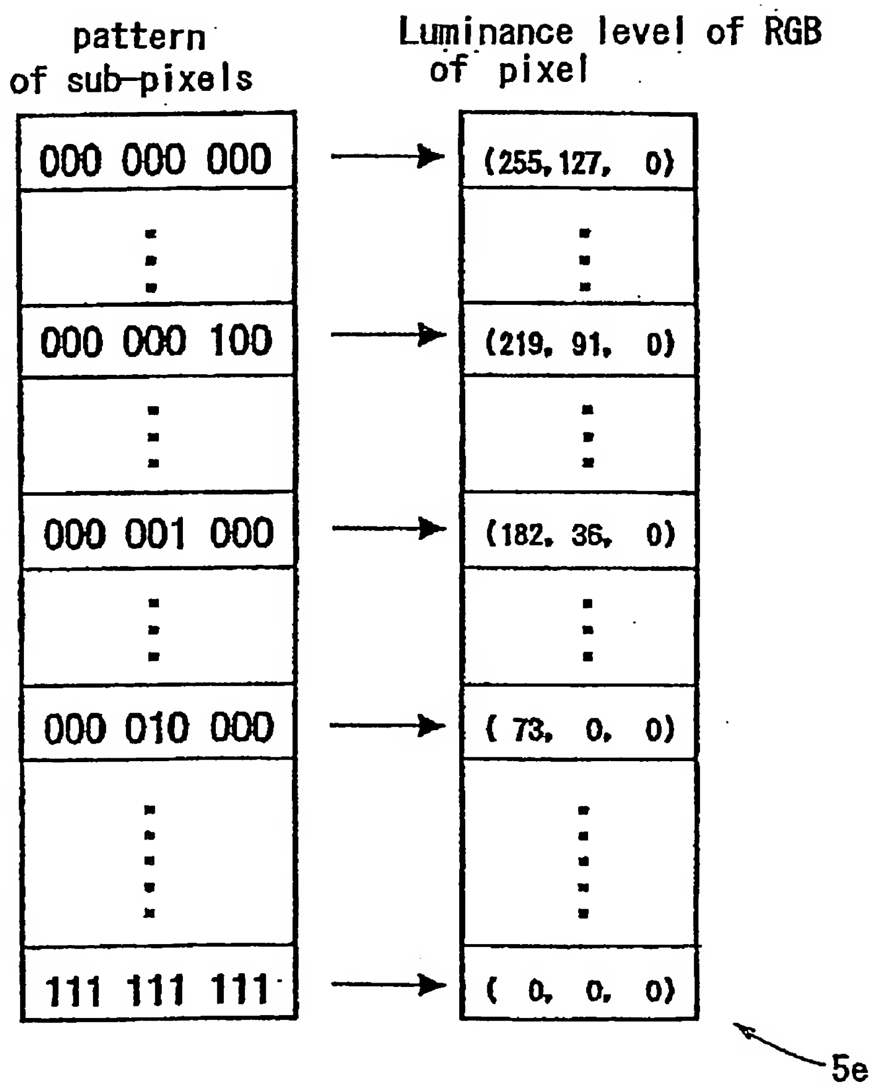
Example of N=M=3

[Figure 6]



Example of N=M=3

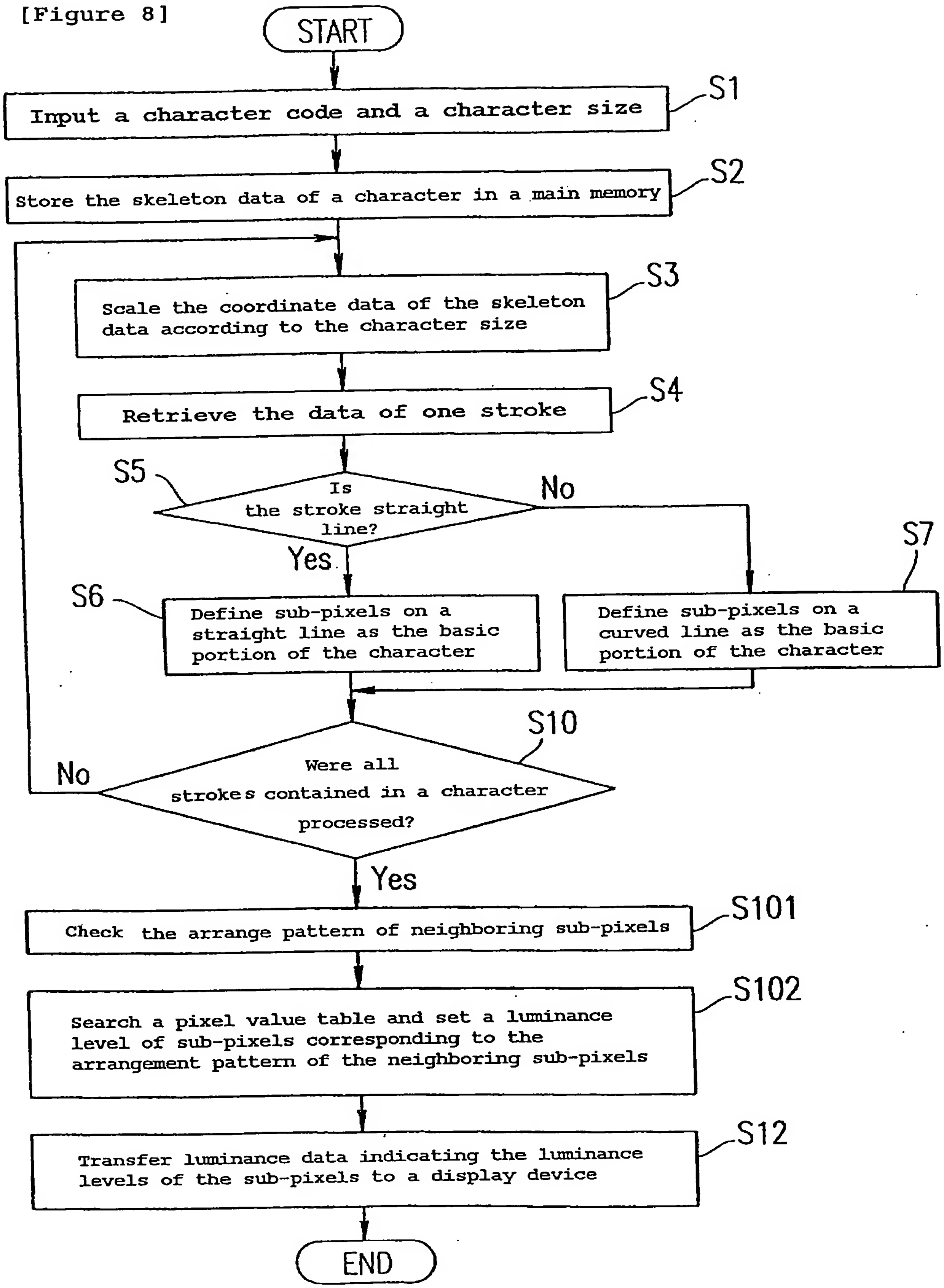
[Figure 7]



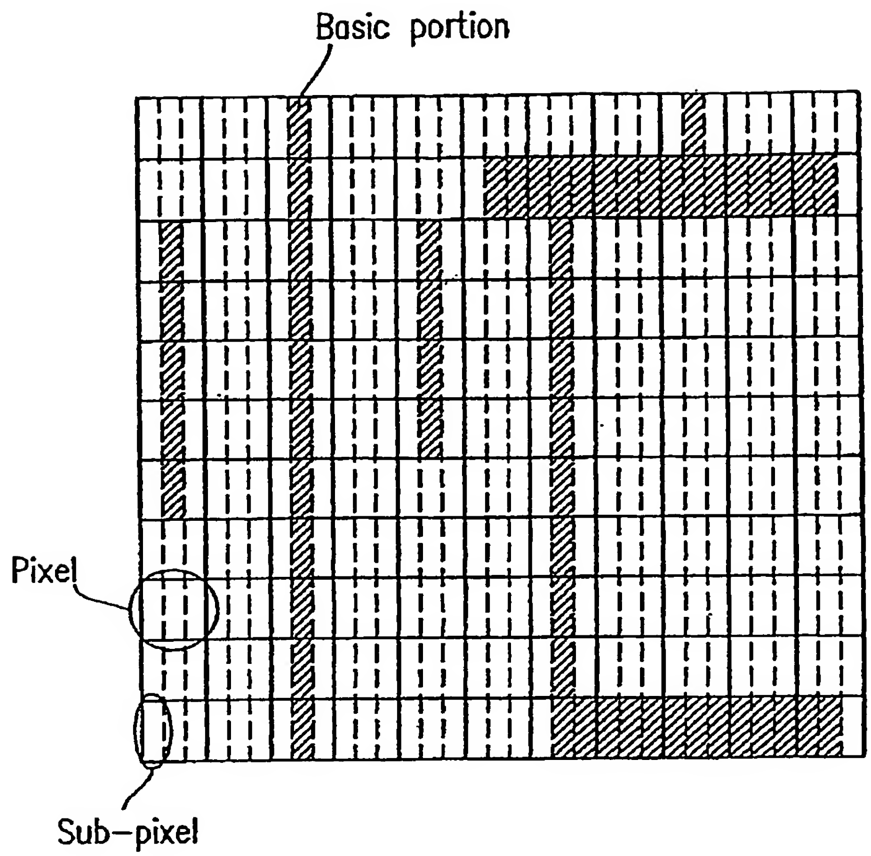
When Background color is orange
(255, 127, 0)

Example of N=M=3

[Figure 8]


START
Input a character code and a character size
S1
Store the skeleton data of a character in a main memory
S2
Scale the coordinate data of the skeleton data according to the character size
S3
Retrieve the data of one stroke
S4
S5
Is the stroke straight line?
No
Yes
S6
Define sub-pixels on a straight line as the basic portion of the character
S7
Define sub-pixels on a curved line as the basic portion of the character
S10
No
Were all strokes contained in a character processed?
Yes
Check the arrange pattern of neighboring sub-pixels
S101
Search a pixel value table and set a luminance level of sub-pixels corresponding to the arrangement pattern of the neighboring sub-pixels
S102
Transfer luminance data indicating the luminance levels of the sub-pixels to a display device
S12
END

[Figure 9]



[Figure 10]

Correction table 5c

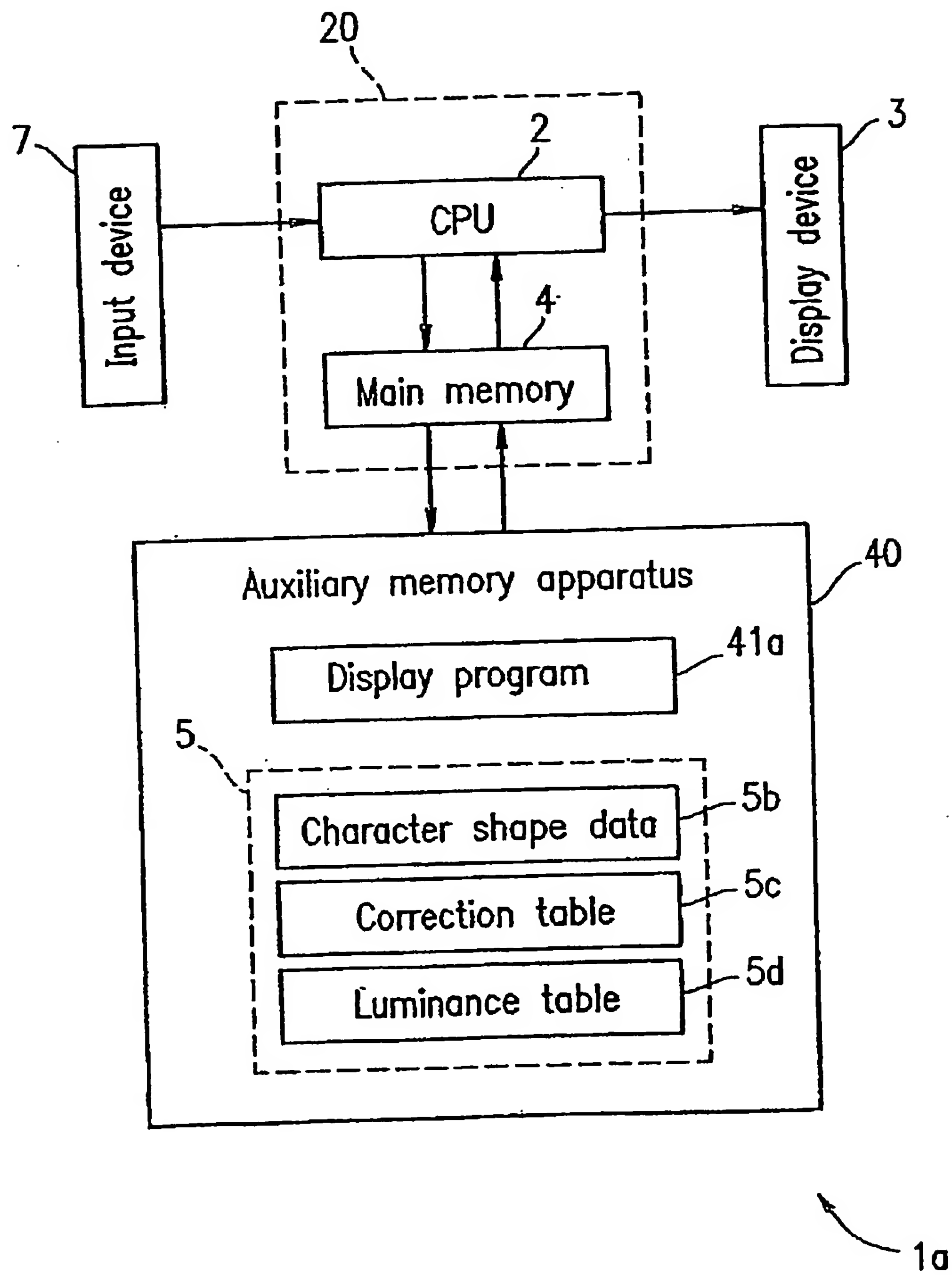
		Correction pattern 1	Correction pattern 2
Color element level	Sub-pixel 1	5	4
	Sub-pixel 2	2	2
	Sub-pixel 3	1	1

[Figure 11]

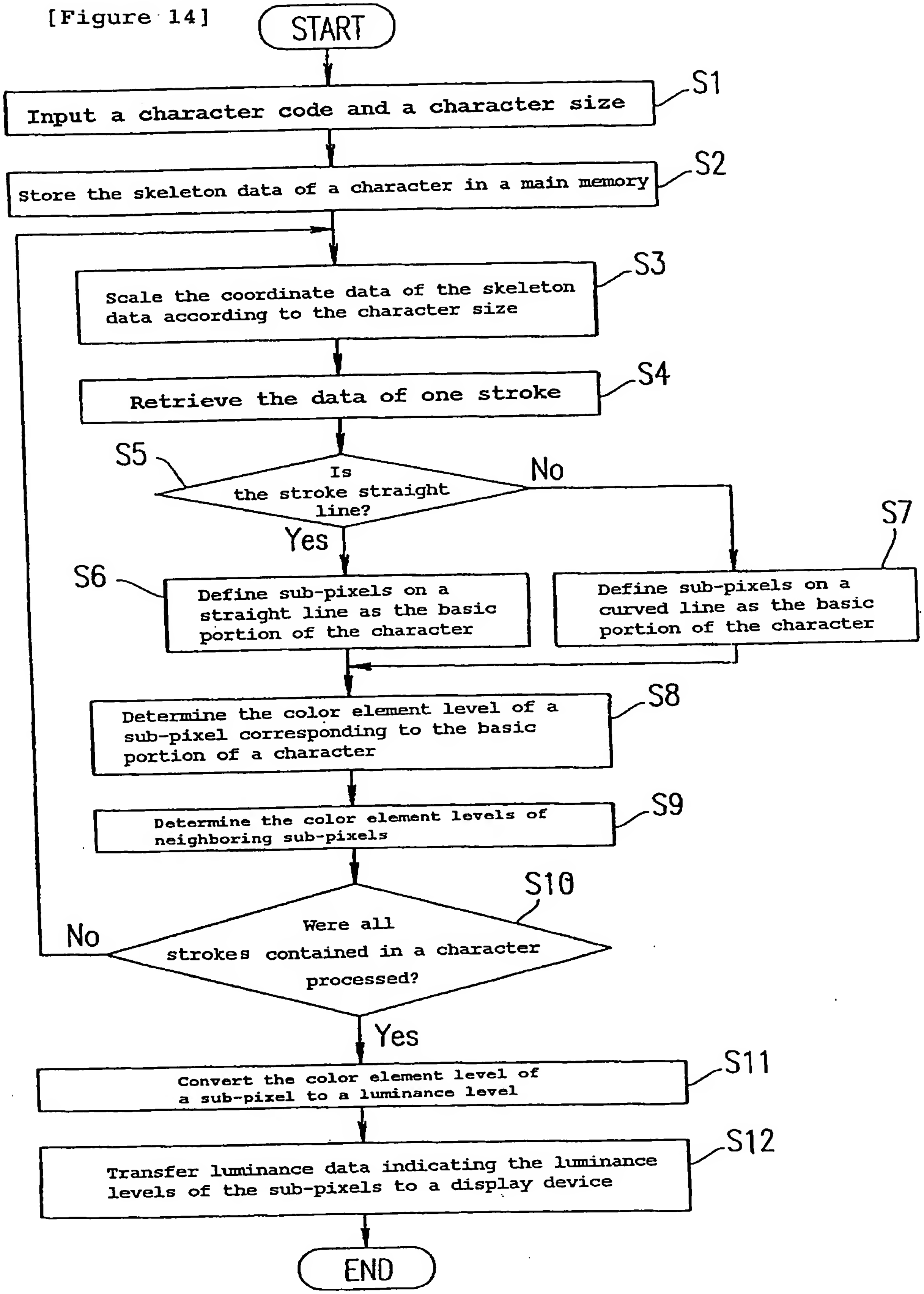
Luminance table 5d

		Luminance level		
		R	G	B
Color element level	7	0	0	0
	6	36	36	36
	5	73	73	73
	4	109	109	109
	3	146	146	146
	2	182	182	182
	1	219	219	219
	0	255	255	255

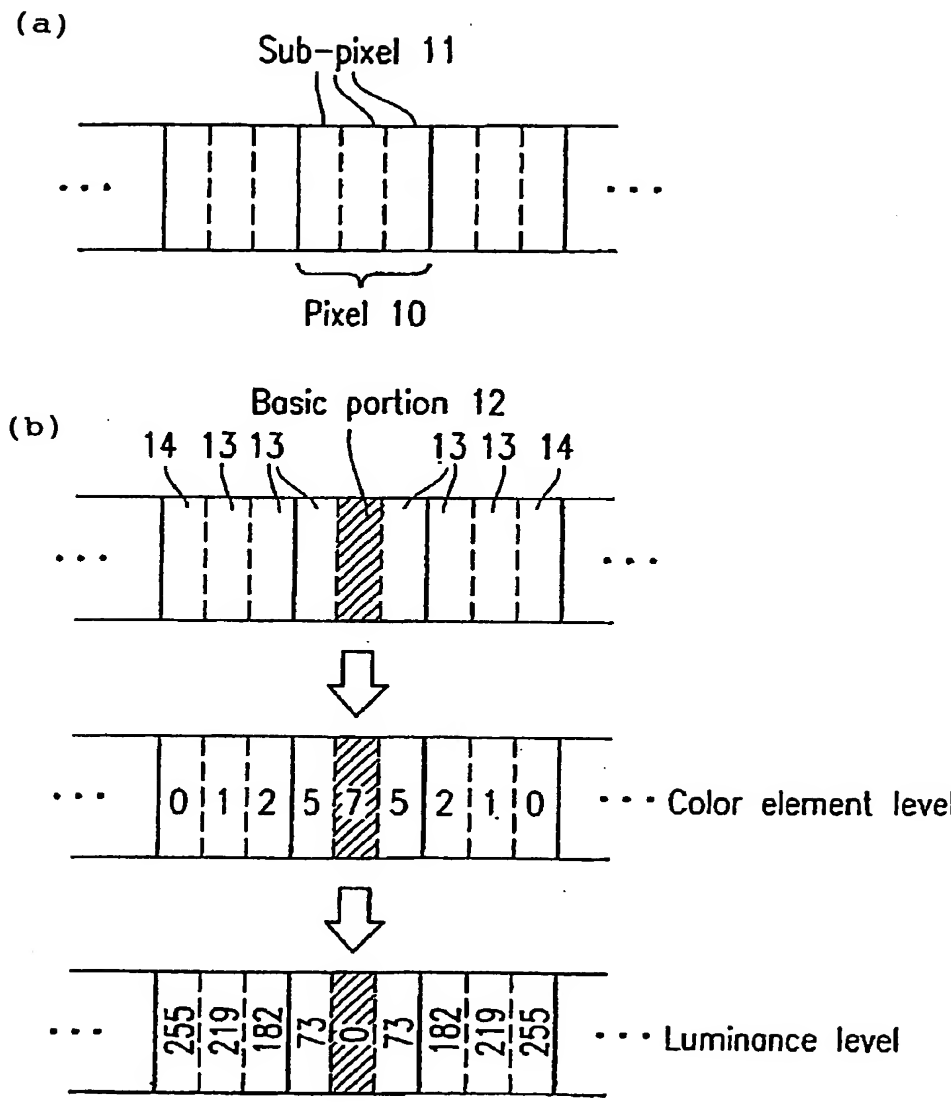
[Figure 12]


20
2
CPU
7
Input device
3
Display device
4
Main memory
Auxiliary memory apparatus
40
Display program
41a
5
Character shape data
5b
Correction table
5c
Luminance table
5d
1a

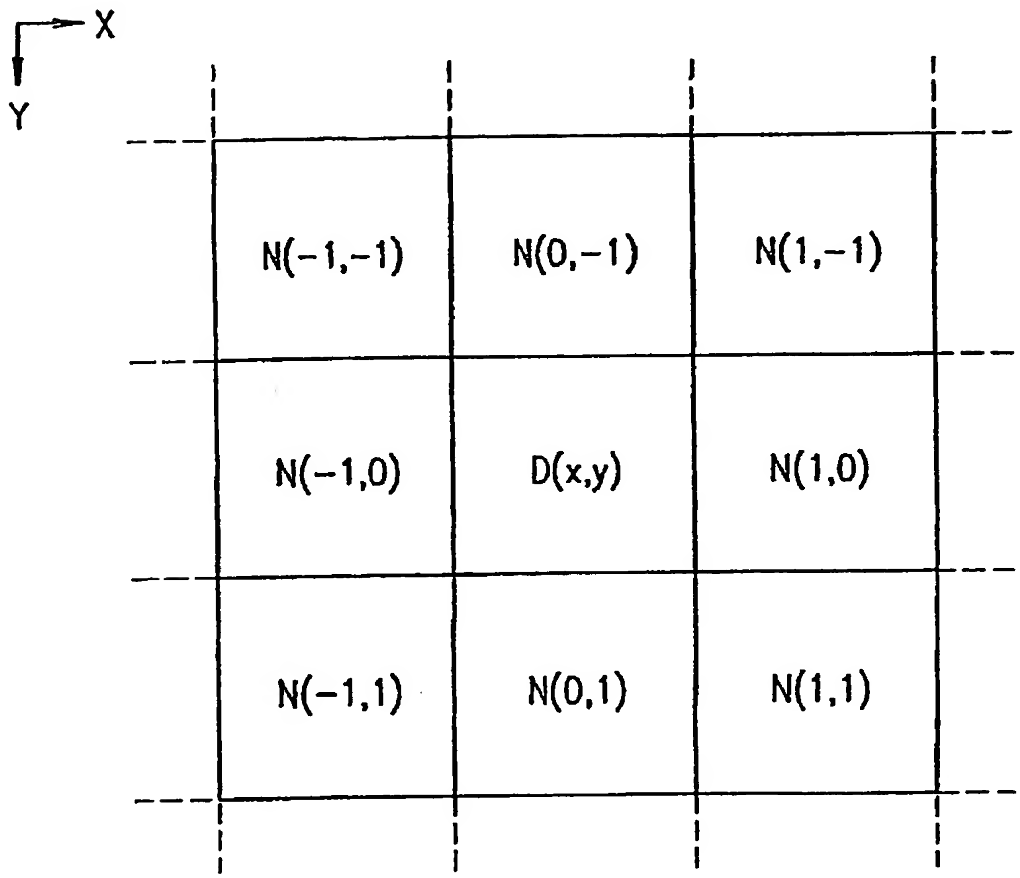
[Figure 14]


START
Input a character code and a character size
S1
Store the skeleton data of a character in a main memory
S2
Scale the coordinate data of the skeleton data according to the character size
S3
Retrieve the data of one stroke
S4
S5
Is the stroke straight line?
No
Yes
S6
Define sub-pixels on a straight line as the basic portion of the character
S7
Define sub-pixels on a curved line as the basic portion of the character
Determine the color element level of a sub-pixel corresponding to the basic portion of a character
S8
Determine the color element levels of neighboring sub-pixels
S9
S10
No
Were all strokes contained in a character processed?
Yes
Convert the color element level of a sub-pixel to a luminance level
S11
Transfer luminance data indicating the luminance levels of the sub-pixels to a display device
S12
END

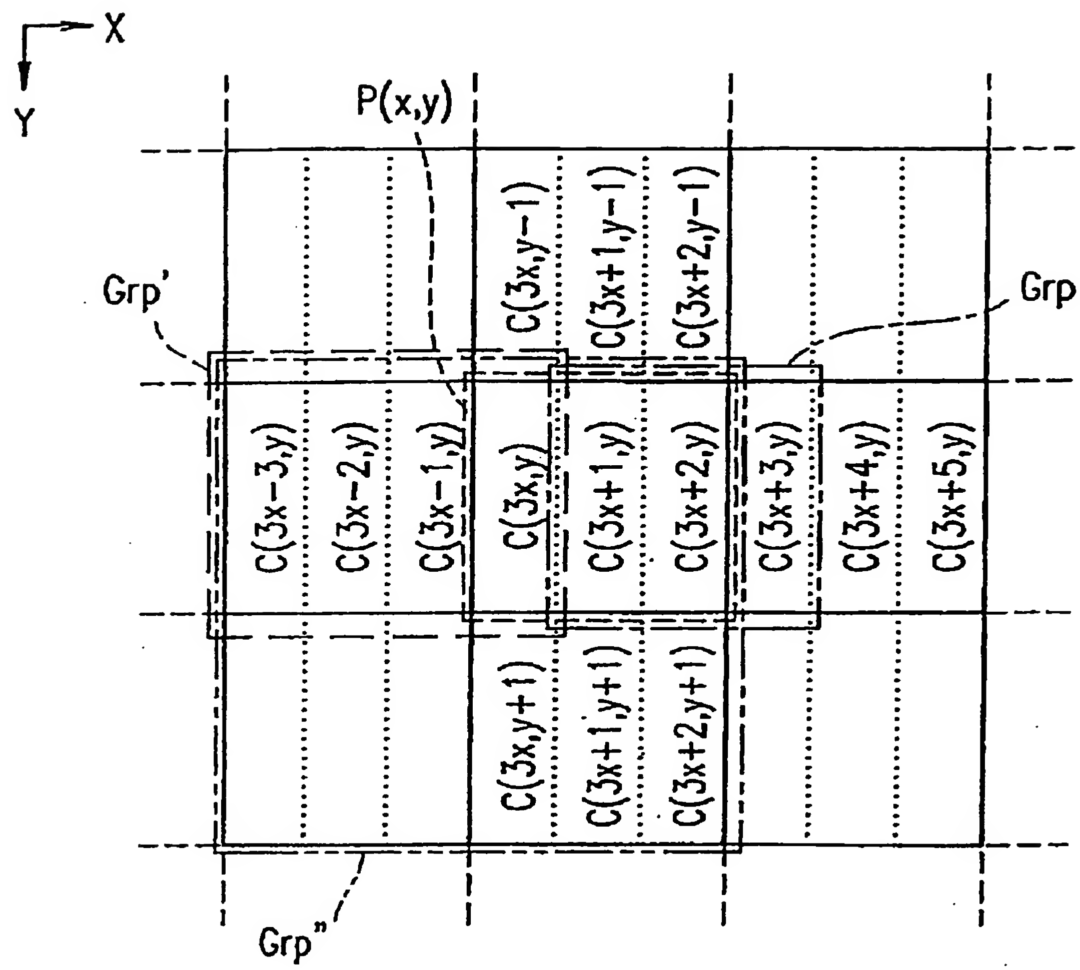
[Figure 13]


(a)
Sub-pixel 11
Pixel 10
(b)
Basic portion 12
14 13 13 13 13 14
0 1 2 5 7 5 2 1 0
Color element level
255 219 182 73 0 73 182 219 255
Luminance level

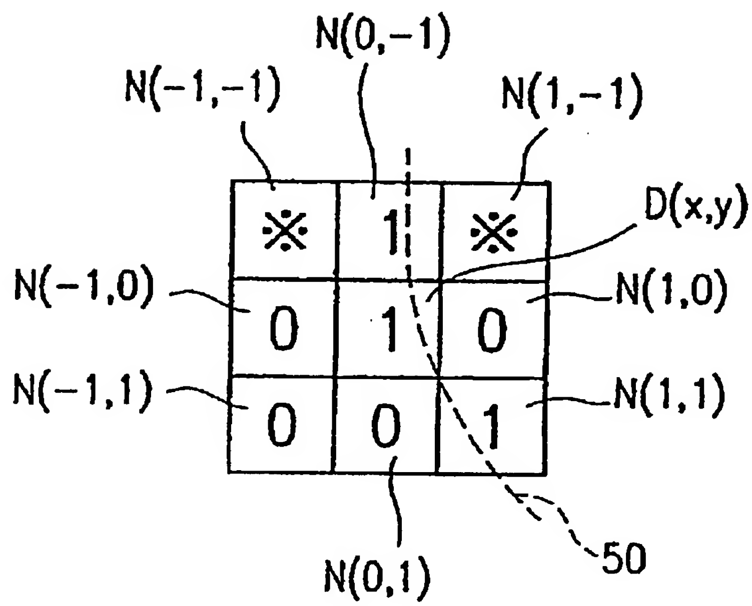
[Figure 15]



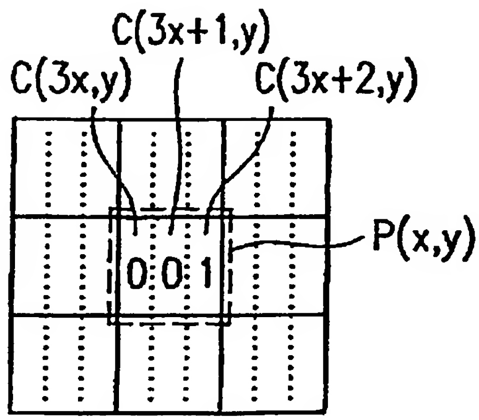
[Figure 16]


X
Y
P(x,y)
Grp'
Grp
Grp"
C(3x,y−1)
C(3x+1,y−1)
C(3x+2,y−1)
C(3x−3,y)
C(3x−2,y)
C(3x−1,y)
C(3x,y)
C(3x+1,y)
C(3x+2,y)
C(3x+3,y)
C(3x+4,y)
C(3x+5,y)
C(3x,y+1)
C(3x+1,y+1)
C(3x+2,y+1)

[Figure 17A]



[Figure 17B]



[Name of the Document] ABSTRACT

[Abstract]
[Problems] Characters with high resolution and definition are displayed by a simple process.

[Means for Solving the Problems] When a character of color is displayed on a display surface of a display device provided with a plurality of pixels each containing sub-pixels arranged in a predetermined direction and each assigned with RGB, a plurality of sub-pixels is associated with a basic portion representing a skeleton of a character, and an arrangement of sub-pixels is extracted from a sub-pixel contained in a pixel whose pixel value is to be determined and from its neighboring sub-pixels. The basic portion is associated with the arrangement of the sub-pixels. Luminance levels of sub-pixels are determined based on the extracted arrangement of the sub-pixels.

[Selected Figure] Figure 8